MULTIMEDIA UNIVERSITY TM

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FINAL EXAMINATION

TRIMESTER 1, 2017/2018

EMG4066 – ANTENNA AND PROPAGATION

(TE)

14 OCTOBER 2017
2.30 P.M.–4.30 P.M.
(2 Hours)

INSTRUCTION TO STUDENT

1.This Question paper consists of 7 pages including cover page with 4 Questions only.

2. Attempt **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the answer Booklet provided.

Question 1

(a) A hypothetical isotropic antenna is radiating in free-space. At a distance of 100 m from the antenna, the total electric field (E_θ) is measured to be 5 V/m. Find the

(i) power density (P_{ave})

(ii) power radiated (P_{rad})

[8 marks]

(b) The power radiated by a lossless antenna is 10 watts. The directional characteristics of the antenna are represented by the radiation intensity of

$U = 6.3662\cos^3\theta$, for $0 \le \theta \le \pi/2$, $0 \le \phi \le 2\pi$. Find the following.

(i) Maximum power density (in watts/square meter) at a distance of 1,000m (assume far field distance).

(ii) Directivity of the antenna (in dB).

(iii) Gain of the antenna (in dB).

[4+2+2 marks]

(c) With an aid of diagram, describe the fields surrounding an antenna.

[9 marks]

Continued...

Question 2

(a) Consider an antenna with normalized radiation intensity is given by

$$U(\theta,\phi)=\begin{cases}1, & \text{for } 0\le\theta\le 60^{o} \text{ and } 0\le\phi\le 2\pi \\ 0 & \text{elsewhere.}\end{cases}$$

Determine
i) Directivity
ii) Beam solid angle

[5+3 marks]

(b) RT/Duroid 5880 substrate (ε_r = 2.2 and d = 1.588mm) is to be used to make a resonant rectangular patch antenna of linear polarization. Design such an antenna to work at 2.45 GHz for Bluetooth applications by finding the length and width of the patch antenna.

[12 marks]

(c) Explain main and side lobes in antenna radiation pattern.

[5 marks]

Continued...

Question 3

(a) Calculate the path loss of a 50-km communication link at 2.2 GHz using a transmitter antenna with a gain of 25 dB and a receiver antenna with a gain of 20 dB. What happens to transmission between two apertures as the frequency is increased?

[7 marks]

(b) A communication satellite system radiates a power of 150 W at 6 GHz. The transmitting antenna has a gain of 50 dBi. The receiving antenna has a gain of 25 dBi. If the path loss is assumed to be 200 dB, calculate the length of the radio path and find the received power.

[5+3 marks]

(c) Suppose a transmitter produces a 50W of power.

(i) Express the transmit power in units of dBm and dBW.

[2 marks]

(ii) If the transmitter power is applied to a 1dB gain antenna with a 1800MHz carrier frequency, what is the received power in dBm at free space distance of 100m?

[3 marks]

(iii) Repeat (ii) for a distance of 5km. Conclude your answer.

[5 marks]

Continued...

Question 4

(a) A space wave communication link connects station A and station B operating at 3GHz. The distance between the 2 stations is 36km. The antenna height of station A is 30m. At midway between the 2 stations, there is a 40m high obstacle. The required minimum clearance is 0.8 times the radius of the first Fresnel zone.
Determine the minimum required tower height for the antenna at station B. Take the earth radius to be 6400km and K-factor is 4/3.

[12 marks]

(b) Assume that reflection takes place at a height of 400 km and the maximum density in the ionosphere corresponds to a refractive index of 0.9 at 10 MHz. Assuming that earth is flat, find the range in kilometers for which Maximum Usable Frequency (f_{MUF}) is 10 MHz.

[6 marks]

(c) With an aid of diagram, explain the meaning of skip zone and skip distance in sky wave propagation.

[7 marks]

End of paper.

APPENDIX

Constants and Formulae (All symbols have their usual meanings)

Constants and Formulae:

Boltzmann's constant	$k = 1.38 \times 10^{-23} J/k$
Plank's constant	$h = 6.6266 \times 10^{-34} J.s$
Light velocity in free space	$c = 3 \times 10^{8} m/s$
Electron Charge	$e = 1.6 \times 10^{-19} C$
Permeability of free space	$\mu_o = 4\pi \times 10^{-7} H/m$
Permittivity of free space	$\varepsilon_o = \frac{10^{-9}}{36\pi} F/m$

Friss Transmission & Propagation

$$P_r = P_t \frac{G_t G_r}{d^4}(h_t h_r)^2 \qquad P_{rad} = 40\pi^2 \left[\frac{L}{\lambda}\right]^2 I_m^2$$

$$P_D = \frac{P_{tx} G_{tx}}{4\pi R_{tx}^2}$$

$$h_{inc} = \frac{D_1 D_2}{2KR} \qquad r = \sqrt{\frac{D_1 D_2 \lambda}{D_1 + D_2}}$$

$$P_R = \frac{|E|^2}{120\pi} A_e \qquad E_R = 2\frac{E_0}{d}\sin\left(\frac{2\pi}{\lambda} \bullet \frac{h_t h_r}{d}\right)$$

$$E = \frac{\sqrt{30 P_t \bullet G_t}}{d} \qquad MUF = f_{cr} Sec\theta_i \qquad n = \sqrt{\varepsilon_r} = \frac{\sin\theta_i}{\sin\theta_r} = \sqrt{1 - \frac{81N}{f^2}}$$

$$d = 2R\left[(\pi/2 - \beta) - \sin^{-1}\left(\frac{R}{R+h}\cos\beta\right)\right] \qquad d_{\max.single\text{-}hop} = 2R\cos^{-1}\left(\frac{R}{R+h_{\max}}\right)$$

$$h_{eff\ obs} = h_{inc} + h_{obs} + 1st.FZ \qquad D = 2h_v\sqrt{\left(\frac{f_{MUF}}{f_c}\right)^2 - 1}$$

$$d = \sqrt{2KRh_{tx}} + \sqrt{2KRh_{rx}}$$

Antenna

$$P_{ave} = \frac{1}{2}\left[\mathrm{Re}(E \times H^*)\right] = \frac{E^2}{2\eta}\hat{a}_r$$

$$R = 2D^2 / \lambda$$

$$D = \frac{4\pi U_{\max}}{P_{rad}}$$

$$P_{rad} = \oint_S P_{ave}\, dS = \oint_S P_{ave} r^2 \sin\theta \, d\theta \, d\varphi$$

$$= \int_S U(\theta,\varphi)\sin\theta \, d\theta \, d\varphi$$

$$= \int_{\varphi=0}^{2\pi}\int_{\theta=0}^{\pi} U(\theta,\varphi)\, d\Omega$$

$$W = \frac{1}{2f_r\sqrt{\varepsilon_0\mu_0}}\sqrt{2/(\varepsilon_r+1)}$$

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2\sqrt{1+12d/W}}$$

$$L = \frac{1}{2f_r\sqrt{\varepsilon_{reff}}\sqrt{\mu_0\varepsilon_0}} - 2\Delta L$$

$$U_{ave} = \frac{P_{rad}}{4\pi}$$

$$\frac{\Delta L}{h} = 0.412\frac{\left(\varepsilon_{reff}+0.3\right)\left(\frac{W}{h}+0.264\right)}{\left(\varepsilon_{reff}-0.258\right)\left(\frac{W}{h}+0.8\right)}$$

$$P_r = \frac{P_t}{4\pi r^2}$$

$$D(\theta,\phi) = \frac{U(\theta,\phi)}{\frac{1}{4\pi}\iint U(\theta,\phi)\, d\Omega}$$

$$A_e = \frac{D\lambda^2}{4\pi}$$

$$P_r = \frac{1}{2}\left[\frac{|V_{oc}|}{2R_{rad}}\right]^2 R_{rad} = \frac{|V_{oc}|^2}{8R_{rad}}$$

$$R_{rad} = 80\pi^2\left[\frac{L}{\lambda}\right]^2$$